Society of Vascular Surgery Vascular Registry® comparison of carotid artery stenting outcomes for atherosclerotic vs nonatherosclerotic carotid artery disease

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Objective: **The Vascular Registry (VR) on carotid procedures collects long-term outcomes on carotid artery stenting (CAS) and carotid endarterectomy (CEA) patients. The purpose of this report is to describe in-hospital and 30-day CAS outcomes in patients with atherosclerotic carotid artery disease (CAD; atherosclerosis [ATH]) compared to recurrent carotid stenosis (RES) and radiation-induced stenosis (RAD).**

Methods: **The VR collects provider-reported data on CAS using a Web-based data management system. For this report, data were analyzed at the preprocedure, procedure, predischarge, and 30-day intervals.**

Results: **As of November 20, 2008, there were 4017 patients with CAS with discharge data, of which 72% were due to ATH. A total of 2321 patients were available for 30-day outcomes analysis (1623 ATH, 529 restenosis, 119 radiation, 17 dissection, 3 trauma, and 30 other). Baseline demographics showed that ATH occurred in older patients (72-years-old), had the greatest history of coronary artery disease (CAD; 62%), myocardial infarction (MI; 24%), valvular heart disease (8%), arrhythmia (16%), congestive heart failure (CHF; 16%), diabetes mellitus (DM; 35%), and chronic obstructive pulmonary disease (COPD; 20%). RES had a higher degree of baseline stenosis (87.0 vs 85.8 ATH; $P = .010$), were less likely to be symptomatic (35.5% vs 46.3% ATH; $P < .001$), but had a greater history of hypertension, peripheral vascular disease (PVD), and smoking. RAD was seen in younger patients (66.6 vs 71.7 ATH; $P < .001$), were more likely to be male (78.2% vs 60.9% ATH; $P < .001$), and had less comorbidities overall, with the exception of amaurosis fugax, smoking, and cancer. The only statistically significant difference in perioperative rates was in transient ischemic attack (TIA; 2.7% ATH vs 0.9% RES; $P = .02$). There were no statistically significant differences in in-hospital death/stroke/MI (ATH 5.4%, RES 3.8%, RAD 4.2%) or at 30 days (ATH 7.1%, RES 5.1%, RAD 5.0%). Even after adjusting for age, gender, symptomatology, CHF, and renal failure, the only statistically significant difference at 30 days was amaurosis fugax between ATH and RAD (odds ratio [OR] 0.13; $P = .01$).**

Conclusion: **Although patients with ATH have statistically significant comorbidities, they did not have statistically significant increased rates of death/stroke/MI during hospitalization or within 30 days after discharge when compared to RES or RAD. The CAS event rates for ATH vs RES and RAD are similar, despite prior published reports. Symptomatic ATH have statistically significant higher rates of death/stroke/MI compared to asymptomatic cohort. Finally, consistent and accurate entry of long-term data beyond initial hospitalization is essential to fully assess CAS outcomes since a significant number of adverse events occur in the interval from hospital discharge to 30 days. (J Vasc Surg 2010;51:1116-23.)**

In the United States, stroke is the leading cause of serious long-term disability and the third leading cause of death.[1] Stroke is the most devastating complication of carotid artery stenosis, and atherosclerosis (ATH) is the leading etiology of carotid artery disease. Other etiologies include recurrent carotid stenosis (restenosis [RES]) and radiation-induced (RAD) or accelerated carotid ATH, which are considered high-risk factors for carotid endarterectomy (CEA).

It has been reported that recurrent carotid stenosis (or restenosis) occurs in approximately 20% of patients having an interventional carotid procedure (prior carotid artery stenting [CAS] or CEA), mostly asymptomatic.[2,3] Given the reported high event rates for carotid revascularization with redo CEA, CAS is frequently the preferred alternative to operative management in these patients.[4]

Radiation-induced or accelerated stenosis is a well-defined entity and can occur up to 20 years after treatment.[5] Because stenotic lesions in this cohort are reported to be multiple, long, surgically less accessible, consisting primarily of fibrotic tissue, and at high risk for cranial nerve palsy, CAS is felt by many to be the preferred intervention compared to CEA.[4,6]

In 2008, the Society for Vascular Surgery (SVS) issued clinical practice guidelines suggesting CAS for the treat-

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ment of symptomatic patients with moderate-to-severe carotid stenosis (≥50%) and high perioperative risk, which includes recurrent stenosis or radiation therapy to the neck.[7]

As part of the rapid evolution in vascular interventional techniques, there is a need for methods to assess efficacy of CAS and compare these results in routine clinical practice to conventional surgical procedures. Continued improvement in surgical interventions and the rapid development of CAS interventional devices and methods makes ongoing comparison of CEA and CAS imperative to ensure quality improvement.

In response to this need, the Vascular Registry (VR) on carotid procedures was developed to collect long-term outcomes on patients with CAS and CEA.[8] As the first societal registry to enroll patients with CAS and CEA, the VR is the largest published database of CAS procedures in the United States. As the most representative sample of carotid artery procedures in the United States, the VR is a wealth of information for studying the indications for CAS. Whereas much is known about CAS procedures for the primary indication of ATH, less is known about the total experience with stenting including, for example, radiation-induced stenosis.

The purpose of this report is to describe in-hospital (procedural and predischarge) and 30-day outcomes in patients treated with CAS comparing atherosclerotic CAD (ATH) with nonatherosclerotic CAD (mainly restenosis [RES] and radiation-induced stenosis [RAD]).

METHODS

VR data are reported by providers through Web-based electronic data capture. The measurement schedule includes baseline (preoperative) information such as demographics, medical history, carotid symptom status, preprocedural diagnostic imaging and laboratory, procedural information including clinical utility, procedural and predischarge complications; and follow-up information such as postprocedure mortality, stroke, myocardial infarction (MI), and other morbidity. All data entered into the VR are fully compliant with the Health Insurance Portability and Accountability Act (HIPAA) regulations and are auditable. All data reports and analyses performed include only deindentified and aggregated data.

The New England Research Institutes, Inc (NERI, Watertown, Mass) maintains the online database. Funding for the administration and database management of the VR has been provided by the Society of Vascular Surgery (SVS, Chicago, Ill).

Outcomes. The primary outcome measures are combined death, stroke, and MI. Stroke is defined as any nonconvulsive, focal neurologic deficit of abrupt onset persisting more than 24 hours. The ischemic event must correspond to a vascular territory. An MI is classified as either Q wave MI in which one of the following criteria is required: (1) chest pain or other acute symptoms consistent with myocardial ischemia and new pathologic Q waves in two or more contiguous electrocardiogram (ECG) leads; or (2) new pathologic Q waves in two or more contiguous ECG leads and elevation of cardiac enzymes; or non-Q wave MI, which is defined as CK ratio >2 and CK-MB >1 in the absence of new, pathologic Q waves. In addition, although not considered specific outcomes but of interest, transient ischemic attack (TIA) and amaurosis fugax (or transient monocular blindness [TMB]) are also reported. Analysis of the 30-day outcomes were based on only those patients who had at least a 30-day follow-up visit (≥15 days) or experienced an endpoint (death, stroke, or MI) within 30 days of treatment.

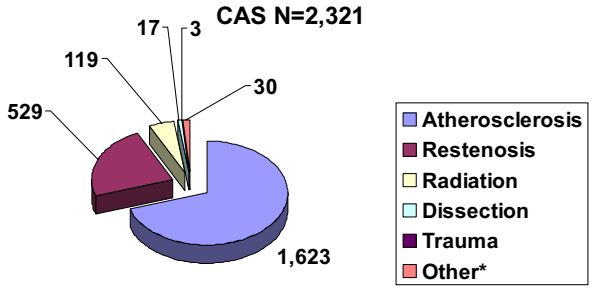

Fig 1. Carotid artery disease etiology for all carotid artery stenting (CAS) patients. *Other includes aneurysm, pseudoaneurysm, fibromuscular dysplasia, multiple and unknown etiologies.

Procedural success data were also collected. A CAS procedure is deemed successful when all of its components are completed without the need of conversion to CEA, or its abandonment before completion, and <30% residual stenosis is achieved postprocedure.

Statistical methods. Tests of statistical significance were conducted with χ^2 or Fisher's exact tests for categoric variables and analysis of variance (ANOVA) for continuous variables. Descriptive statistics are listed as mean ± SD for continuous variables and percent (frequency) for categoric variables. Subset analyses were performed using the two-tailed *t* test for continuous variables and the χ^2 or Fisher's exact test, as necessary, for discrete/categoric data. Unadjusted and adjusted odds ratios were used to compare the primary outcomes across treatment groups. Odds ratios were adjusted for age and any significant baseline factors that were kept after using backward elimination methods. Differences were considered significant if $P < .05$. All statistical analyses were performed by NERI using SAS Statistical Software (Cary, NC).

RESULTS

For the purpose of this report, data collected in the VR from the beginning of electronic data entry on July 11, 2005, to November 20, 2008, were analyzed. There were 4017 patients with CAS with procedural and discharge data, of which 72% underwent CAS for ATH. At 30 days, there were 2321 patients with CAS in-hospital and 30-day outcome data available for analysis (1623 ATH, 529 restenosis, 119 radiation, 17 dissection, 3 trauma, and 30 other), as illustrated in Fig 1. For purposes of this report,

Table I. Baseline demographics, medical history, and evaluation of carotid stenosis of patients with carotid artery stenting (CAS) by disease etiology

	ATH (n = 1623) n (%)	*RES (n = 529) n (%)*	*RAD (n = 119) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Demographics					
Age (years)	71.7 ± 10.01	71.1 ± 8.68	66.6 ± 10.02	.24	<.001
Gender (male, %)	989 (60.9%)	277 (52.4%)	93 (78.2%)	<.001	<.001
Race (white, %)	1496 (92.2%)	511 (96.6%)	111 (93.3%)	<.001	.66
Ethnicity (Hispanic, %)	92 (5.7%)	10 (1.9%)	3 (2.5%)	<.001	.21
Medical history					
CAD	1008 (62.1%)	310 (58.6%)	33 (27.7%)	.15	<.001
MI	386 (23.8%)	122 (23.1%)	15 (12.6%)	.77	.005
VHD	128 (7.9%)	21 (4.0%)	1 (0.8%)	.002	.002
CA	255 (15.7%)	45 (8.5%)	13 (10.9%)	<.001	.19
CHF	262 (16.1%)	49 (9.3%)	1 (0.8%)	<.001	<.001
HTN	1331 (82.0%)	446 (84.3%)	84 (70.6%)	.23	.002
DM	562 (34.6%)	154 (29.1%)	23 (19.3%)	.02	<.001
Stroke	404 (24.9%)	134 (25.3%)	24 (20.2%)	.84	.25
TIA	373 (23.0%)	128 (24.2%)	28 (23.5%)	.57	.89
Amaurosis fugax	107 (6.6%)	48 (9.1%)	19 (16.0%)	.07	<.001
COPD	323 (19.9%)	82 (15.5%)	19 (16.0%)	.02	.30
CRF	57 (3.5%)	14 (2.6%)	0 (0.0%)	.40	.03
PVD	586 (36.1%)	229 (43.3%)	27 (22.7%)	.003	.003
GI ulcer/bleeding	70 (4.3%)	31 (5.9%)	5 (4.2%)	.16	>.999
Current or past smoker	914 (56.3%)	341 (64.5%)	82 (68.9%)	<.001	.007
Cancer	248 (15.3%)	59 (11.2%)	110 (92.4%)	.02	<.001
Coagulopathy	13 (0.8%)	7 (1.3%)	3 (2.5%)	.30	.09
ASA grade >3	122 (7.5%)	34 (6.4%)	8 (6.7%)	.44	.86
NYHA >2	219 (13.5%)	43 (8.1%)	10 (8.4%)	<.001	.12
Carotid evaluation					
Symptomatic	752 (46.3%)	188 (35.5%)	60 (50.4%)	<.001	.39
Baseline stenosis (%)	85.8 ± 9.12	87.0 ± 8.85	83.2 ± 13.35	.010	.03
Stenosis >80%	1016 (63.1%)	360 (68.4%)	67 (56.3%)	.03	.14
Baseline ultrasound >80% stenosis	1080 (66.5%)	399 (75.4%)	84 (70.6%)	<.001	.37
Contralateral stenosis	405 (25.0%)	131 (24.8%)	29 (24.4%)	.95	>.999
Stents deployed	1.1 ± 0.33	1.1 ± 0.27	1.2 ± 0.42	.07	.02
Embolic protection	1549 (95.4%)	512 (96.8%)	106 (89.1%)	.18	.002
Stent type					
Open	1080 (79.4%)	321 (75.9%)	62 (78.5%)	.12	.84
Closed	280 (20.6%)	102 (24.1%)	17 (21.5%)		
Anti-platelet use	1588 (97.8%)	520 (98.3%)	111 (93.3%)	.60	.007

ATH, Atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *CAD,* coronary artery disease; *MI,* myocardial infarction; *VHD,* valvular heart disease; *CA,* cardiac arrhythmia; *CHF,* congestive heart failure; *HTN,* hypertension; *DM,* diabetes mellitus; *TIA,* transient ischemic attack; *COPD,* chronic obstructive pulmonary disease; *CRF,* chronic renal failure; *PVD,* peripheral vascular disease; *GI,* gastrointestinal; *ASA,* American Society of Anesthesiology; *NYHA,* New York Heart Association.

P values are based on χ^2 tests for categoric variables and *t* tests for continuous variables.

comparisons will be made between ATH vs RES and radiation (RAD).

Baseline demographics, seen in Table I, showed that patients with ATH were the oldest (71.7-years-old), had the greatest history of CAD (62.1%), MI (23.8%), valvular heart disease (7.9%), cardiac arrhythmia (15.7%), congestive heart failure (CHF; 16.1%), diabetes mellitus (DM; 34.6%), chronic obstructive pulmonary disease (COPD; 19.9%), and were the most likely to have a NYHA Class >2 (13.5%). Recurrent stenosis patients had a higher degree of baseline stenosis than patients with ATH (87.0 vs 85.8; $P = .010$), were less likely to be symptomatic (35.5% vs 46.3%; $P < .001$), but had a greater history of hypertension, peripheral vascular disease (PVD), and smoking. Radiation-induced patients were younger than patients with ATH (66.6 vs 71.7; $P < .001$), were more likely to be male (78.2% vs 60.9%; $P < .001$), and had less comorbidities overall, with the exception of amaurosis fugax, smoking, and cancer.

In-hospital outcomes. The only statistically significant difference in in-hospital (includes procedure and predischarge on initial hospitalization) adverse event rates comparing ATH to RES or RAD was in TIA (2.7% ATH vs 0.9% RES; $P = .02$; Table II, *A*). When comparing both disease etiology and presentation (eg, symptomatology), as expected, there were some statistically significant differences, with symptomatic patients having higher in-hospital event rates in general, compared with asymptomatic patients (Table II, *B*). In the ATH cohort, symptomatic patients had a higher combined death/stroke/MI rate (7.2% vs 3.8% asymptomatic [ASYMP]; $P = .003$) and a higher stroke rate (5.5% vs 3.0% ASYMP; $P = .02$). In the

Table II. A, In-hospital (intraprocedural and predischarge) outcomes of carotid artery stenting (CAS) patients by disease etiology

Peri-op AEs	*ATH (n = 1623) n (%)*	*RES (n = 529) n (%)*	*RAD (n = 119) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Death/stroke/MI	87 (5.4%)	20 (3.8%)	5 (4.2%)	.17	.83
Death/stroke	74 (4.6%)	18 (3.4%)	5 (4.2%)	.32	>.999
Mortality	14 (0.9%)	6 (1.1%)	1 (0.8%)	.60	>.999
Stroke	67 (4.1%)	14 (2.6%)	5 (4.2%)	.15	>.999
MI	20 (1.2%)	3 (0.6%)	0 (0.0%)	.23	.39
TIA	44 (2.7%)	5 (0.9%)	1 (0.8%)	.02	.36
Amaurosis fugax	5 (0.3%)	1 (0.2%)	2 (1.7%)	>.999	.08

ATH, Atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *AE,* adverse event; *MI,* myocardial infarction; *TIA,* transient ischemic attack.
P values are based on Fisher's exact test.
Events are defined as any AE occurring intraprocedural or predischarge.
Event rates are reported per-patient.

Table II. B, In-hospital (intraprocedural and predischarge) outcomes of patients with carotid artery stenting (CAS) by disease etiology and symptomatology

	ATH			*RES*			*RAD*		
Peri-op AEs	*SYMPT (n = 752) n (%)*	*ASYMP (n = 871) n (%)*	P *value*	*SYMPT (n = 188) n (%)*	*ASYMP (n = 341) n (%)*	P *value*	*SYMPT (n = 60) n (%)*	*ASYMP (n = 59) n (%)*	P *value*
Death/stroke/MI	54 (7.2%)	33 (3.8%)	.003	10 (5.3%)	10 (2.9%)	.23	4 (6.7%)	1 (1.7%)	.36
Death/stroke	43 (5.7%)	31 (3.6%)	.04	9 (4.8%)	9 (2.6%)	.21	4 (6.7%)	1 (1.7%)	.36
Mortality	7 (0.9%)	7 (0.8%)	.79	1 (0.5%)	5 (1.5%)	.43	1 (1.7%)	0 (0.0%)	>.999
Stroke	41 (5.5%)	26 (3.0%)	.02	9 (4.8%)	5 (1.5%)	.04	4 (6.7%)	1 (1.7%)	.36
MI	12 (1.6%)	8 (0.9%)	.26	1 (0.5%)	2 (0.6%)	>.999	0 (0.0%)	0 (0.0%)	.36
TIA	23 (3.1%)	21 (2.4%)	.45	5 (2.7%)	0 (0.0%)	.005	0 (0.0%)	1 (1.7%)	.50
Amaurosis fugax	1 (0.1%)	4 (0.5%)	.38	1 (0.5%)	0 (0.0%)	.36	1 (1.7%)	1 (1.7%)	>.999

ATH, Atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *AE,* adverse event; *SYMPT,* symptomatic; *ASYMP,* asymptomatic; *MI,* myocardial infarction; *TIA,* transient ischemic attack.
P values were based on Fisher's exact tests.

Table III. A, In-hospital (intraprocedural and predischarge) outcomes of symptomatic patients with carotid artery stenting (CAS) by disease etiology

	Symptomatic				
Peri-op AEs	*ATH (n = 752) n (%)*	*RES (n = 188) n (%)*	*RAD (n = 60) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Death/stroke/MI	54 (7.2%)	10 (5.3%)	4 (6.7%)	.42	>.999
Death/stroke	43 (5.7%)	9 (4.8%)	4 (6.7%)	.72	.77
Mortality	7 (0.9%)	1 (0.5%)	1 (1.7%)	>.999	.46
Stroke	41 (5.5%)	9 (4.8%)	4 (6.7%)	.86	.57
MI	12 (1.6%)	1 (0.5%)	0 (0.0%)	.48	>.999
TIA	23 (3.1%)	5 (2.7%)	0 (0.0%)	>.999	.40
Amaurosis fugax	1 (0.1%)	1 (0.5%)	1 (1.7%)	.36	.14

AE, Adverse event; *ATH,* atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *MI,* myocardial infarction; *TIA,* transient ischemic attack.

recurrent stenosis cohort (RES), symptomatic patients had a higher in-hospital rate of stroke (4.8% vs 1.5% ASYMP; $P = .04$) and TIA (2.7% vs 0% ASYMP; $P = .005$). The differences between symptomatology in in-hospital event rates in the radiation-induced cohort did not reach statistical significance, however, the numbers were small. When comparing in-hospital outcomes of symptomatic patients receiving CAS by disease etiology (Table III, *A*), there were no statistically significant differences. However, it is interesting to note that patients with ATH had higher rates of MI and TIA, and patients with RAD had high rates of mortality, stroke, and amaurosis fugax. In asymptomatic patients (Table III, *B*), patients with ATH had a statistically significant higher in-hospital rate of TIA compared with patients with RES (2.4% vs 0%; $P = .001$). Of note, although not statistically significant, the asymptomatic RES

Table III. B, In-hospital (intraprocedural and predischarge) outcomes of asymptomatic patients with carotid artery stenting (CAS) by disease etiology

	Asymptomatic				
Peri-op AEs	*ATH (n = 871) n (%)*	*RES (n = 341) n (%)*	*RAD (n = 59) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Death/stroke/MI	33 (3.8%)	10 (2.9%)	1 (1.7%)	.60	.72
Death/stroke	31 (3.6%)	9 (2.6%)	1 (1.7%)	.48	.72
Mortality	7 (0.8%)	5 (1.5%)	0 (0.0%)	.33	>.999
Stroke	26 (3.0%)	5 (1.5%)	1 (1.7%)	.16	>.999
MI	8 (0.9%)	2 (0.6%)	0 (0.0%)	.73	>.999
TIA	21 (2.4%)	0 (0.0%)	1 (1.7%)	.001	>.999
Amaurosis fugax	4 (0.5%)	0 (0.0%)	1 (1.7%)	.58	.28

AE, Adverse event; *ATH,* atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *MI,* myocardial infarction; *TIA,* transient ischemic attack.

Table IV. A, Thirty-day outcomes of patients with carotid artery stenting (CAS) by disease etiology

30-day AEs	*ATH (n = 1623) n (%)*	*RES (n = 529) n (%)*	*RAD (n = 119) n (%)*	P *value ATH vs RES*	P *value ATH vs RAD*
Death/stroke/MI	116 (7.1%)	27 (5.1%)	6 (5.0%)	.11	.46
Death/stroke	98 (6.0%)	24 (4.5%)	6 (5.0%)	.23	.84
Mortality	23 (1.4%)	9 (1.7%)	2 (1.7%)	.68	.69
Stroke	82 (5.1%)	17 (3.2%)	5 (4.2%)	.09	.83
MI	25 (1.5%)	4 (0.8%)	0 (0.0%)	.20	.41
TIA	52 (3.2%)	9 (1.7%)	1 (0.8%)	.07	.26
Amaurosis fugax	6 (0.4%)	1 (0.2%)	2 (1.7%)	>.999	.10

AE, Adverse event; *ATH,* atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *MI,* myocardial infarction; *TIA,* transient ischemic attack.
P values are based on Fisher's exact test.
Events are defined as any AE occurring intraprocedure, predischarge, or after discharge to 30 days.
Event rates are reported per-patient.

Table IV. B, Thirty-day outcomes of patients with carotid artery stenting (CAS) by disease etiology and symptomatology

	ATH			*RES*			*RAD*		
30-day AEs	*SYMPT (n = 752) n (%)*	*ASYMP (n = 871) n (%)*	P *value*	*SYMPT (n = 188) n (%)*	*ASYMP (n = 341) n (%)*	P *value*	*SYMPT (n = 60) n (%)*	*ASYMP (n = 59) n (%)*	P *value*
Death/stroke/MI	67 (8.9%)	49 (5.6%)	.01	12 (6.4%)	15 (4.4%)	.41	4 (6.7%)	2 (3.4%)	.68
Death/stroke	54 (7.2%)	44 (5.1%)	.08	11 (5.9%)	13 (3.8%)	.28	4 (6.7%)	2 (3.4%)	.68
Mortality	10 (1.3%)	13 (1.5%)	.84	1 (0.5%)	8 (2.3%)	.17	1 (1.7%)	1 (1.7%)	>.999
Stroke	49 (6.5%)	33 (3.8%)	.02	11 (5.9%)	6 (1.8%)	.02	4 (6.7%)	1 (1.7%)	.36
MI	14 (1.9%)	11 (1.3%)	.42	1 (0.5%)	3 (0.9%)	>.999	0 (0.0%)	0 (0.0%)	.36
TIA	28 (3.7%)	24 (2.8%)	.32	8 (4.3%)	1 (0.3%)	.001	0 (0.0%)	1 (1.7%)	.50
Amaurosis fugax	1 (0.1%)	5 (0.6%)	.23	1 (0.5%)	0 (0.0%)	.36	1 (1.7%)	1 (1.7%)	>.999

ATH, Atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *AE,* adverse event; *SYMPT,* symptomatic; *ASYMP,* asymptomatic; *MI,* myocardial infarction; *TIA,* transient ischemic attack.
P values were based on Fisher's exact tests.

cohort had a higher mortality rate (1.5% vs 0.8% ATH vs 0% RAD).

Thirty-day outcomes. There were no statistically significant differences in 30-day (includes in-hospital through 30 days) adverse event rates between ATH and RES or RAD in the primary outcome of combined stroke/death/or MI, or the individual outcomes of death, stroke, MI, TIA, or amaurosis fugax (or TMB; Table IV, *A*).

When comparing both disease etiology and presentation (eg, symptomatology), as expected there were some statistically significant differences, with symptomatic patients, in general, having higher 30-day event rates compared with asymptomatic patients (Table IV, *B*). Of note, in the ATH cohort, symptomatic patients had a higher combined death/stroke/MI rate (8.9% vs 5.6% ASYMP; $P = .01$) and a higher stroke rate (6.5% vs 3.8% ASYMP; $P = .02$), which was similar to what was observed perioperatively. In the recurrent stenosis cohort (RES), symptomatic patients had a higher 30-day rate of stroke (5.9% vs 1.8% ASYMP; $P = .02$) and TIA (4.3% vs 0.3% ASYMP; $P =$

Table V. A, Thirty-day outcomes of symptomatic patients with carotid artery stenting (CAS) by disease etiology

	Symptomatic				
30-day AEs	*ATH (n = 752) n (%)*	*RES (n = 188) n (%)*	*RAD (n = 60) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Death/stroke/MI	67 (8.9%)	12 (6.4%)	4 (6.7%)	.31	.81
Death/stroke	54 (7.2%)	11 (5.9%)	4 (6.7%)	.63	>.999
Mortality	10 (1.3%)	1 (0.5%)	1 (1.7%)	.70	.57
Stroke	49 (6.5%)	11 (5.9%)	4 (6.7%)	.87	>.999
MI	14 (1.9%)	1 (0.5%)	0 (0.0%)	.33	.62
TIA	28 (3.7%)	8 (4.3%)	0 (0.0%)	.68	.26
Amaurosis fugax	1 (0.1%)	1 (0.5%)	1 (1.7%)	.36	.14

AE, Adverse event; *ATH,* atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *MI,* myocardial infarction; *TIA,* transient ischemic attack.

Table V. B, Thirty-day outcomes of asymptomatic patients with carotid artery stenting (CAS) by disease etiology

	Asymptomatic				
30-day AEs	*ATH (n = 871) n (%)*	*RES (n = 341) n (%)*	*RAD (n = 59) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Death/stroke/MI	49 (5.6%)	15 (4.4%)	2 (3.4%)	.48	.77
Death/stroke	44 (5.1%)	13 (3.8%)	2 (3.4%)	.45	.76
Mortality	13 (1.5%)	8 (2.3%)	1 (1.7%)	.33	.60
Stroke	33 (3.8%)	6 (1.8%)	1 (1.7%)	.10	.72
MI	11 (1.3%)	3 (0.9%)	0 (0.0%)	.77	>.999
TIA	24 (2.8%)	1 (0.3%)	1 (1.7%)	.005	>.999
Amaurosis fugax	5 (0.6%)	0 (0.0%)	1 (1.7%)	.33	.33

AE, Adverse event; *ATH,* atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *MI,* myocardial infarction; *TIA,* transient ischemic attack.

Table VI. Risk-adjusted 30-day outcomes of patients with carotid artery stenting (CAS) by disease etiology

	Unadjusted				*Adjusted*[1]			
	ATH vs RES		*ATH vs RAD*		*ATH vs RES*		*ATH vs RAD*	
	*OR (*P *value)*	*95% CI*	*OR (*P *value)*	*95% CI*	*OR (*P *value)*	*95% CI*	*OR (*P *value)*	*95% CI*
Death/stroke/MI	1.43 (0.55)	0.93-2.20	1.45 (0.66)	0.62-3.37	1.31 (0.47)	0.85-2.03	1.12 (0.96)	0.47-2.63
Death/stroke	1.35 (0.49)	0.86-2.14	1.21 (0.93)	0.52-2.82	1.25 (0.43)	0.79-1.99	0.96 (0.74)	0.41-2.28
Mortality	0.83 (0.84)	0.38-1.81	0.84 (0.91)	0.20-3.61	0.78 (0.84)	0.35-1.71	0.49 (0.44)	0.11-2.20
Stroke	1.60 (0.27)	0.94-2.73	1.21 (0.93)	0.48-3.05	1.46 (0.29)	0.85-2.50	1.03 (0.75)	0.40-2.64
MI	2.05 (0.96)	0.71-5.93	N/A	N/A	1.92 (0.96)	0.66-5.58	N/A	N/A
TIA	1.91 (0.96)	0.94-3.91	3.91 (0.31)	0.54-28.50	1.84 (0.97)	0.89-3.77	3.23 (0.40)	0.44-23.87
Amaurosis fugax	1.96 (0.18)	0.24-16.31	0.22 (0.04)	0.04-1.09	1.90 (0.13)	0.22-16.00	0.13 (0.01)	0.02-0.72

ATH, Atherosclerosis; *RES,* restenosis; *OR,* odds ratio; *CI,* confidence interval; *MI,* myocardial infarction; *N/A,* not applicable; *TIA,* transient ischemic attack.
[1]Adjusted for age, gender, symptomatology, congestive heart failure, and chronic renal failure.

.001), again similar to what was observed with the in-hospital rates. There were no statistically significant differences between symptomatology in 30-day event rates in the radiation-induced cohort.

When comparing 30-day outcomes of symptomatic patients receiving CAS by disease etiology (Table V, *A*), there were no statistically significant differences, which is similar to what was observed in-hospital. However, it is interesting to note that patients with ATH had higher combined event rates (death, stroke, MI) and high rates of MI, and patients with RAD had high rates of mortality, stroke, and amaurosis fugax. In asymptomatic patients (Table V, *B*), patients with ATH had a statistically significant higher 30-day rate of TIA compared with patients with RES (2.8% vs 0.3%; $P = .005$).

Even after adjusting for age, gender, symptomatology, CHF, and chronic renal failure (Table VI), the only statistically significant difference at 30 days was in amaurosis fugax between ATH and radiation cohorts (odds ratio [OR] 0.13; $P = .01$).

It is important to note that although there were few statistically significant differences for combined events between the cohorts, 25% of atherosclerotic events and 24% of the nonatherosclerotic events occurred after the in-hospital period, as illustrated in Fig 2. Approximately 40% of the

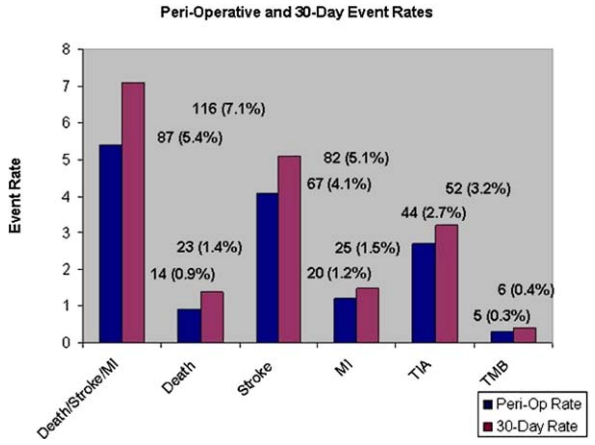

Fig 2. Comparison of perioperative and 30-day event rates.

atherosclerotic deaths and 36% of the nonatherosclerotic deaths occurred after the in-hospital period, which stresses the importance of patient follow-up.

Secondary outcomes. Secondary outcomes are shown by etiology in Table VII. Patients with restenosis had shorter hospital stays on average (1.6 days) than patients with ATH (2.2 days; $P < .001$) and were less likely to experience hypotension requiring treatment (1.3% vs 4.7% ATH; $P < .001$). Patients who received radiation were more likely to experience puncture site complications (2.5% vs 0.2% ATH; $P = .009$).

DISCUSSION

The introduction of CAS to clinical practice has changed the selection criterion of patients with extracranial CAD for surgical intervention. Although there was early enthusiasm that CAS would be favorable for all patients, recent reports are mixed regarding the utility of CAS for asymptomatic patients and for patients with symptomatic lesions with good surgical anatomy.[8,9] In response to the favorable results of CAS from ARCHER and SAPPHIRE for patients who are at high surgical risk or who have unfavorable anatomy for surgery, the Center for Medicare and Medicaid Services (CMS) has offered payment for these patients but has waited for additional data to support broader application.[10,11] Thereafter, randomized controlled trials such as SPACE and EVA-3S demonstrated less favorable results.[12,13]

In response to the need to provide ongoing assessment for the performance of new devices and techniques compared to conventional surgical options, the VR was developed to provide longitudinal data entry. This not only addresses the science needed to answer critical clinical questions but also addresses means to provide quality assurance and fulfill recertification requirements of federal agencies.

In this registry, although patients with ATH appear to be sicker due to statistically significant comorbidities, they did not have statistically significant increased rates of death/stroke/MI in-hospital or 30 days after discharge when compared to other etiologies. Although the VR 30-day results of death/stroke in ATH vs RES are not statistically significant (6% ATH vs 4.5% RES; $P = .84$), AbuRahma et al[14] reported a statistically significant increase in 30-day rates of death/stroke in patients undergoing primary CAS compared with those undergoing CAS for post-CEA restenosis (7.4% primary CAS vs 0.9% restenosis; $P = .03$).[14] However, Cuadra et al[15] reported lower 30-day rates of death/stroke in ATH compared to RES (3.0% ATH vs 5.1% RES; $P = .51$).[15] With continued enrollment and follow-up, analysis of VR will supplement randomized trials by providing CAS outcomes in current clinical practice with sufficient numbers to serve as an outcome assessment tool of important patient subsets.

The current report compares the short-term efficacy of carotid stents in the management of atherosclerotic, recurrent, and radiation-induced carotid lesions.

In a prior report, the VR demonstrated that CEA had better 30-day event rates than CAS, with the 30-day data being valuable in making this determination, as there was a demonstrated increase in event rates from the in-hospital to 30-day interval.[8] A similar increase was noted in this analysis, with the increase in ATH being greater than in the patients with restenosis. An important conclusion of this analysis is the need for a 30-day reporting interval, as the in-hospital event rate in both groups did not reflect the 30-day results.

It is also noteworthy that given the current CMS reporting requirement, only 87 death/stroke/MI events in a little less than 4017 discharges or just over 2.2% events would be reported, compared to 30-day data. One could contend that 30-day event rates with less than 100% follow-up may underestimate, overestimate, or correctly estimate the true 30-day rates depending on whether the presence of follow-up is related to events or the lack thereof. Nevertheless, this discrepancy (2.2% vs 5.4% vs 7.1%) clearly supports a more thorough 30-day analysis.

Finally, it is important to discuss the limitations of VR and the analyses presented. The main weakness of these results is the VR reliance on self-reporting with its biases inherent to any registry-based study, as reported previously.[8] Furthermore, some facilities participating in VR entered either CAS or CEA data only; some institutions do not perform CAS and elected to participate in the registry and enter only CEA data, and others entered only CAS data. In addition, although VR is designed for long-term entry of follow-up, current CMS requirements for CAS facility certification are limited to the initial hospitalization and do not include follow-up. Thus, some facilities are not motivated to enter follow-up information. However, the concurrent entry of all patients treated for CAD in independent and verifiable registries provides valuable information about current clinical practice patterns.

CONCLUSION

Three major conclusions can be drawn from the analyses of registry data. First, that event rates for carotid stent treatment of ATH vs restenosis and radiation therapy patients are similar. This finding differs from results of prior

Table VII. Secondary outcomes for patients with carotid artery stenting (CAS) by etiology

Secondary outcomes	*ATH (n = 1623) n (%)*	*RES (n = 529) n (%)*	*RAD (n = 119) n (%)*	P *value ATH-RES*	P *value ATH-RAD*
Hospital length of stay (days)	2.2 ± 3.59	1.6 ± 3.08	2.1 ± 3.75	<.001	.77
Procedural/technical success	1612 (99.3%)	523 (98.9%)	118 (99.2%)	.39	.57
Intraprocedural events					
Abrupt closure	1 (0.1%)	2 (0.4%)	0 (0.0%)	.15	>.999
Spasm requiring treatment	24 (1.5%)	1 (0.2%)	2 (1.7%)	.02	.70
Loss of external carotid	0 (0.0%)	0 (0.0%)	1 (0.8%)	N/A	.07
Embolization (systemic)	1 (0.1%)	0 (0.0%)	0 (0.0%)	>.999	>.999
Embolization (carotid)	7 (0.4%)	0 (0.0%)	0 (0.0%)	.20	>.999
Thrombosis	6 (0.4%)	2 (0.4%)	1 (0.8%)	>.999	.39
Occlusive untreated dissection	0 (0.0%)	0 (0.0%)	0 (0.0%)	N/A	N/A
Arrhythmia (treated)	35 (2.2%)	4 (0.8%)	2 (1.7%)	.04	>.999
Hypotension (treated)	77 (4.7%)	7 (1.3%)	2 (1.7%)	<.001	.17
Seizure	2 (0.1%)	2 (0.4%)	0 (0.0%)	.25	>.999
Puncture site complication	4 (0.2%)	2 (0.4%)	3 (2.5%)	.64	.009

ATH, Atherosclerosis; *RES,* restenosis; *RAD,* radiation-induced; *N/A,* not applicable.
P values are based on Fisher's exact test.
Event rates are reported per-patient.

published reports. Next, symptomatic patients with ATH etiology had statistically significant higher rates of death/stroke/MI both periprocedurally and at 30 days compared with the asymptomatic patients with atherosclerotic etiology. And finally, consistent entry of patient data beyond in-hospital (ie, intraprocedural and predischarge) event rates, as currently mandated by CMS, is required to determine the true risks. This finding supports the importance of continued data reporting in the postprocedure intervals to enable accurate assessment of procedural success.

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Final approval of the article: RW, GS, RZ, AS, MS, FS
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